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A Comparison of VO_2 Measurement Obtained by a Physiological Monitoring Device and the Cosmed Quark CPET

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Abstract

The purpose of this study was to compare the results of measurements of VO_2 as obtained by the Zephyr Bioharness (ZB) and the Cosmed Quark CPET Metabolic cart (CM). Both ZB and CM have been proven reliable by previous research. The ZB is portable and offers many practical advantages over CM, which requires greater expertise and expense, and tests must be completed in a laboratory setting. Aerobic capacity was assessed in a sample of college students (n=33). Subjects performed a maximal test using a treadmill protocol. Mean Ventilation (VE), mean heart rates (HR), respiratory exchange ratios (RER), and aerobic capacity (VO_2) were similar using both the ZB and the CM, with no significant differences observed. Because data varied very little, both methods are comparable, which indicates ZB is a practical solution for monitoring physiological variables outside of a laboratory setting.

Keywords

Aerobic capacity; Zephyr bioharness; Fitness testing; Validity

Introduction

Measuring oxygen uptake is a vital part of research and assessment in exercise physiology. VO_2 max has come to represent the basic measure in performance capabilities for endurance activities. Maximal VO_2 is representative of performance considering the attainment of maximal aerobic capacity requires the involvement of the cardiovascular, ventilatory, and neuromuscular systems. Researchers have spent considerable amounts of time attempting to develop and standardize tests for VO_2 max and establishing normality as it relates to other factors that influence maximal VO_2, such as age, gender, body composition, and training state. Standards that are developed have to be practical so they can relate to field situations; several confounding variables and factors must be considered. Obtaining an accurate measurement of maximal aerobic capacity can become problematic in regards to the size of the equipment, the ease of use, the accuracy of the data, and the cost of the equipment.

Research involving direct measurement of oxygen uptake has been restricted to the laboratory setting for the most part due to lack of portability in metabolic testing equipment. Successful attempts have been made to validate portable systems [1–3]. A valid portable system improves research in areas where activities cannot be performed in the laboratory, such as sports-specific activity, and allows direct measurement in an uncontrolled environment.

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The Zephyr Bioharness (Zephyr Technology, New Zealand) was developed for use in both laboratory and non-laboratory settings. It weighs 2 oz and measures physiological and biomechanical variables including heart rate, respiratory rate, body temperature, acceleration, and position.

The purpose of this study was to compare the results of measurement and estimation of maximal VO_2, by measuring heart rate and respiratory rate directly with the ZB, and using the traditional breath-by-breath method of measurement with the CM, as obtained through two different mechanisms. They are both accepted methods of obtaining heart rate and respiratory rate, and can estimate maximal aerobic capacity. CM uses indirect spirometry for metabolic measures, while ZB utilizes heart rate and respiratory rate for estimation.

Materials and Methods

Participants

Study participants consisted of 23 males and 15 females possessing high activity levels. Characteristic data is shown in table 1. Informed consent was obtained prior to testing.

Testing protocol

Each group completed two identical tests for aerobic capacity, each on different days. During the first exercise session, the subjects wore a mask for gas collection, and wore the ZB. They were tested on the Cosmed Quark CPET system, using a breath-by-breath analysis. During the second test, the mixing chamber was used. Both tests were performed maximal exercise on Woodway treadmill, at a speed chosen by the subject, tests were performed using Quark CPET testing system and software. Both machines were calibrated between each test. Ventilation volume (Ve), oxygen consumption (VO_2), and Respiratory Exchange Ratio (RER), were recorded. Heart rate (HR) was obtained by use of a ECG with 12 leads. Rate of perceived exertion was also recorded every two minutes. Subjects exercised to maximal exertion, or volational fatigue. Each subject completed at least 5 stages of 2 minutes each.

Results

Maximal and submaximal values for Ve, VO_2, HR, and RER were compared for both methods of collection. Means, standard deviations, and percent differences for each measure, between each test, are listed in table 2. Table 3 shows average data for ZB *vs*. CM for each stage of exercise.

The largest difference was seen in measures of VO_2. For male subjects, a 27% difference is noted. There was a 17% difference for both males and females in respiratory rate. Lower percent differences were noted for Ve, HR, and RPE during the tests. In table 3, comparable values are seen for each stage of exercise. Figure 1 compares the average physiological measures taken by ZB and CM for each sex.

Discussion

The estimation and direct measurement of aerobic capacity by the use of both ZB and CM instrumentation has been found to be comparable and reliable. The CM measuring procedure becomes problematic when trying to make adaptations to field conditions, particularly if testing is to be sport specific. The instrument of choice for measuring VO_2 would then be based on the setting in which the testing will be performed.

The results of this study indicate that the mean values for VO_2, VE, and RER are similar when comparing ZB to CM. A 27% difference between VO_2 max of each group indicates that although the values are not much different, there is a constant error present. The difference between the other physiological values is lower, but is still constant among subjects.

The error in measurement begins to become visible at maximal levels of exercise. Submaximal values are more comparable than values obtained at max. This finding is similar to previous studies of ZB, which also indicate more accuracy is found at submaximal levels [4].

When comparing the two instruments, the preferred method of measuring VO_2 would be dependent on the environment in which the testing needed to be done. Sports-specific and field-testing would best be done with the ZB. The discrepancies found in testing would not be enough to overcome the constructive data that can be obtained through field use of the ZB. The ZB allows more versatility in testing because it can be used in places other than the lab and can test sport specific performance. Another advantage of the ZB is that the design provides comfort to the participant while performing the test with no mask needed. When subjects were asked which method they preferred, they determined both methods were of similar comfort level, but that the ZB was less cumbersome. Because the CM is an accepted and reliable method of determining aerobic capacity, it should still be used in the lab setting.

In conclusion, the ZB has proven to be comparable to the CM for use in measurement of aerobic capacity. The slight difference noted between the systems does not outweigh benefits that can be obtained through using ZB when data needs to be collected outside a lab setting.

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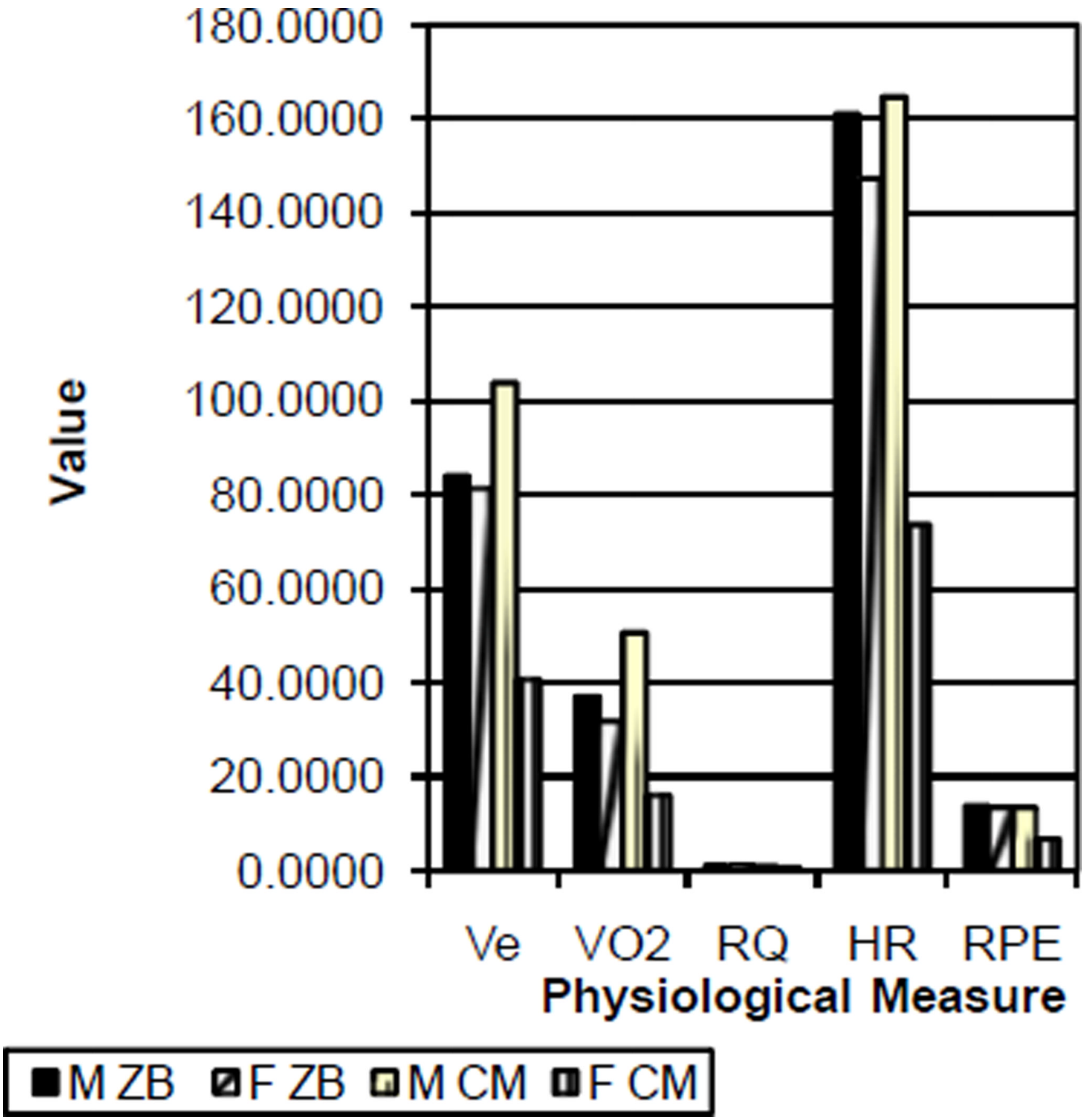

Figure 1.
A comparison of average physiological measures.

Table 1

Subject characteristics.

Subjects	Ht	Wt	%BF	Age
Males	182.9	89.4	9.4	26.5
Females	172.3	77.2	21.9	24.3

Table 2

Mean data and Standard deviations of maximal physiological variables, and % difference between ZB and CM for males and females.

Males					
ZB		Ve (btps)	VO_2 (ml/kg)	HR (bts/min)	RPE
	Ave	84.03	37.1	161	13.8
	St Dev	27.7	12.6	19.3	4.6
CM	Ave	103.8	50.7	164.6	13.4
	St Dev	30.5	12.4	17.4	7.08
	% Diff	19%	26.80%	2.10%	2.90%
Females		Ve (btps)	VO_2 (ml/kg)	HR (bts/min)	RPE
ZB	Ave	81.3	31.8	147.3	13.4
	St Dev	12.5	6.7	17.7	5.6
CM	Ave	40.7	16.03	73.6	6.7
	St Dev	48.6	17.7	91.6	5.5
	% Diff	8.90%	27.10%	3.30%	7.50%

Table 3

ZB *vs*. CM average data for each stage of exercise.

CM	**Ve**	**VO_2**	**HR**	**RPE**
Stage 1	86.8	36.5	155.2	13.6
Stage 2	85.6	34.7	158.5	15.1
Stage 3	86.4	34.0	159.9	16.3
Stage 4	77.1	30.1	143.2	15.3
Stage 5	60.7	23.1	117.7	12.1
Stage 6	44.8	17.3	88.2	7.5
ZB	Ve	VO2	HR	RPE
Stage 1	96.5	47.2	158.5	12.9
Stage 2	101.7	48.6	160.8	14.6
Stage 3	103.3	49.1	162.3	14.87
Stage 4	91.3	42.2	136.9	13.7
Stage 5	89.5	40.1	130.4	13.3
Stage 6	80.8	34.9	117.0	11.5